students were shown how to use the index in getting up their speeches. Schedules were also made and posted a day or two in advance of the debates, in which the names of all the speakers were listed in order, with a word or two as to how they stood on the proposition under discussion. This schedule was used as a guide by the person occupying the chair. It was convenient in prompting students who did not know just when they were to speak.

Some of the members by States were: George Mason, Edmund Randolph, and James Madison of Virginia; Patterson and Houston of New Jersey; Roger Sherman, and Ellsworth of Connecticut; Hamilton of New York; Pinckey of South Carolina; Gouverneur Morris of Pennsylvania; and Rufus King of Massachusetts.

When the day set for our first debate began Mr. Gorham, of Massachusetts, took the chair and acted as moderator while Mr. Randolph, acting for the Virginia delegation, read the Virginia Plan. Debate began and was in spirited progress when interrupted by the arrival of delegates from distant States. James Madison was there, taking copious notes but saying very little. When a vote was called for, each state delegation voted as a unit. For several days we debated, as the members of the Convention did, the advantages and disadvantages of the Virginia Plan. The "small-states" men spoke often and freely of their determination not to be swallowed up by Virginia and Massachusetts.

When the last day's debate was over and the Connecticut Compromise carried by a scant majority we felt that we had won a real victory. The phrases of the Constitution had been invested with a new meaning.

We now see Article I, Sections 1, 2, and 3 against a background brilliant with the figures of intelligent patriotic men whose thoughts we have studied, whose arguments we have reproduced, and whose viewpoint we have shared. To an extent we have partaken of their task and have helped to frame the Constitution of the United States of America.

WHY ARE TIDES INVERTED?

By PROFESSOR A. H. PATTERSON
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QUITE recently my attention was called, not for the first time, to the very unsatisfactory treatment of the subject of the tides in the average text-book used in the schools, whether in Astronomy, Physical Geography, or Geology. A puzzled teacher came to me to get some help on the subject, and as a result of our talk I took occasion to look over a number of texts, such as Davis, Gilbert and Brigham, Redway, Dryer, Hopkins, and others, to see whether the treatment of the tides showed any improvement in recent years. Not one of these mentioned the "inversion" of the tides, by which term is meant *the occurrence of high tides where low tides would be expected by theory, and vice versa.*

I have often wondered how the teachers in our tidewater schools get by with the usual explanation, which calls for high tide under the moon, when every observant boy knows that *low* tide follows the moon. But the teachers are only quoting the text-book, and are not to be blamed.

The authors of the texts, however, cannot be excused so easily, for there is plenty of literature on the subject. The articles on tides in the encyclopedias are full and explicit, and there are various books on the subject—for example, "The Tides," by G. H. Darwin—which give a correct and interesting explanation of the matter.

First, let us consider the Static, or Equilibrium Theory of the tides. Suppose a rod 250,000 miles long were stuck through the center of the earth and the center of the moon, leaving them just as far apart as at present. The rod would then extend entirely through the earth and the moon, and stick out a little at each end. The earth is of course supposed to stop rotating on its axis as it does now, or else it would break our supposed rod, but the earth and moon are both to keep up their monthly revolution about the center of gravity of the earth-moon system, as at present.

This center of gravity is on our supposed rod, 3,000 miles from the center of the earth, so that while the moon would swing around every month in a circle 236,000 miles in radius, the center of the earth would swing around in a circle 3,000 miles in radius. Now the ocean on the side of the earth away from the moon is 4,000 miles further from the center of gravity of the system than is the center of the earth, so that the water of this ocean will travel around every month in a circle *7,000 miles in radius, and will be subjected to a centrifugal force which will heap up the water in a tidal wave.* This is why a tide is raised on the side of the earth away from the moon.

Now how is it raised on the side of the earth *toward* the moon? The attraction of the moon on the

water is far too small to lift it up bodily, of course, but it does make the water somewhat lighter. Then the moon's attraction for the water of our northern and southern oceans is directed toward the center of the moon, of course, which means that *there is a component of this attraction tangential to the earth's surface, which sweeps the water towards the equatorial regions of the earth, and raises a tide.* This tide on the side of the earth toward the moon is a little larger than that on the side away from the moon.

Now in our supposed case, these two tides would be stationary on the earth's surface, the highest part of the tides being at the places where our supposed connecting rod emerges from the earth. That is, high tide would be at the sub-lunar point, exactly under the moon, and there would be no "lag" at all. Notice, please, that we have supposed the earth and moon to move in circles; in reality they move in ellipses, not circles, but this would make little difference in the theory. A much more important correction, however, is that we cannot forget that the earth is not strung on a rod, but is rotating rapidly, turning every side to the moon every twenty-four hours. This means that the two sides raised by the moon are held fixed in space, while the earth rotates between them, just as a wagon wheel turns between two stationary brake-blocks. Of course to us on the earth it appears that we are stationary and the tide is rolling westward, but the truth is that the tides stand still in space, and we travel eastward to meet them. Now the tides in rolling over the surface of the earth have to encounter a lot of viscous friction, and the moon has to drag them over shallows, between islands, etc., so it is not strange that the tide is caused to "lag" or fall behind the moon, in such a way that the crest of the tidal wave will not be immediately under the moon, but will "follow the moon" at an interval of about two hours, as a rule. Of course the time of lag will depend on the depth of oceans, shape of gulfs, etc., through which the tide is dragged.

This corrected "Equilibrium" theory,—corrected for the rotation of the earth on its axis every day,—is called the "Dynamic" theory of the tides, *and still calls for high tide approximately under the moon, allowing for the lag, of course.* But no matter what our theory may wish the tides to do, they proceed to do as they please, and *low tides actually come just where we expect high tides.* Is our theory wrong, or have we left out some factor which explains this apparent contradiction? What is the answer? It lies in a principle of dynamics which may be simply illustrated as follows: take a stick,—a yardstick or meter rod will do,—and bore a hole near one end. Slip a nail through this hole, and support the stick by holding the nail in your fingers. Now let the stick swing like a pendulum, and note the time of a single free swing. Suppose it is three-fourths of a second. We call this *the period of free vibration* about the nail, or the *free period.* If with our nail we give the rod even the slightest impulse to and fro every three-fourths of a second, we soon get the rod swinging through a wide arc. But suppose we give it an impulse to and fro every *second,* instead of every *three-fourths of a second,* what do we get? The stick will swing, but not so easily as before, because we are forcing it to swing in a period which is not its natural free period. Nevertheless, its swings will be *in phase with the impulses,* so that when we move the nail to the right the stick will swing to the right, and when we move the nail to the left the stick swings to the left. The vibration of the stick is in phase with the impulses, and *this always happens when the forced period is equal to or greater than the free period.*

Now let us move the nail back and forth every *half* second, and note the behavior of the stick. It will swing in the forced period of half a second, *but its swings will be inverted,* and when we move the nail to the right the stick will swing to the left. This is exactly opposite to what we got before, and *this out-of-phase result always happens when the forced period is less than the free period.*

Now what has all this talk about the free and forced periods of a swinging stick to do with the tides? Just this: suppose a high tidal wave should be produced near the equator by some other cause than the moon,—say by a depth bomb. The wave would pass over the ocean at a speed which would depend on the depth of the water and nothing else. With our present average depth of oceans, the wave would move about 500 miles an hour, so it would take it about fifty hours to go entirely around the equator, if the continents did not prevent. So the *free period* of the wave would be about *fifty hours.* But when the tide is raised *by the moon,* its speed is not governed by the depth of the water; it is dragged by the moon, and must go as fast as the moon seems to go round the earth, that is, once around in *a little less than twenty-five hours,* and this is the *forced period* imposed on the tides by the moon. *But this forced period is less than the free period of fifty hours, and this means inverted motion,* just as in the case of the stick. So we get an "inversion" of the tides, causing low tides to come when we would naturally expect high tides, and *vice versa.*

This means that the lag of the tide, which would be ordinarily about two hours, is increased to about eight hours. At New York the time elasping between the passage of the moon over the meridian and the arrival of high tide is eight hours and thirteen minutes,

and this time is technically called the "establishment of the port."

Now, of course, if the earth were small enough, or the oceans deep enough, to enable the tides, of their own accord, to go round the earth in less than twenty-five hours, then the forced period due to the moon would be greater than their free period, there would be no inversion, and high tides would follow close under the moon. This actually happens in latitudes greater than 60° north or south, for the distance around the earth at latitude 60° is only one-half what it is on the equator, the tides therefore go round in half the time, or 25 hours, and the free and forced periods are the same. In about that latitude, consequently, the inverted tides of the tropical regions of the earth change to the direct tides of the sub-artic regions, and where this change occurs *there are no tides,*—that is, no rise and fall of the water, but only tidal *currents* running appproximately north and south.

Of course the whole subject of the tides is rendered complex by local conditions, such as prevailing ocean currents, shape or bays and gulfs, etc. Thus we have sometimes prodigious tides, like those in the Bay of Fundy, the Mersey River, the mouths of the Chinese rivers, and elsewhere.

In this discussion we have considered only the influence of the moon in raising the tides, but the statements we have made apply to the sun as well, though the tides raised by the sun are less than half as high as those due to the moon. When the two bodies are working together at new and full moon the tides are "spring" or strong tides; when they are working at cross purposes, as at first and third quarter of the moon, the tides are weak or "neap" tides. But we cannot fairly and intelligently understand the theory of the tides without taking into account the inversion of the tides, and its cause, and this the current text-books, almost without exception, leave out entirely.

CLUBS---A REGULAR SOCIAL ACTIVITY

By MARY A. SHEEHAN
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GENERAL JAN SMUTS, one of the outstanding figures at the Peace Conference, crystalized the spirit of the times when he said, "Civilization has struck her tents and is once more on the march." Education, the great leader of humanity, must always take her place among the foremost in the van. According as she sets the pace, so will the civilization of future generations have moved forward or backward.

The schools of the past were in many ways like great grist mills. They took in the grist—little children—passed them all through the same grinding process, and, regardless of background or of natural talent, turned all out in the same way. The work aside of man was cared for. Although the play element in human nature is strong, it was often ignored and left to shift for itself, the idea being that man would play anyway. He did do it "anyway" and many drifted into pleasures that were often not only unprofitable, but sometimes unwholesome.

Those schools, however, have served their purpose and experience paves the way to better things. The schools of the present and of the future cannot pass all through the same process. Life is too complex, individual differences must be reckoned with. Today Education is taking cognizance of all these things and is trying to make "the school for the children, not the children for the school." The National Committee on the Reorganization of Secondary Education embodies the aims that contribute to a complete education under seven main objectives. One of these wisely heeds the play nature in man and provides for the "worthy use of leisure." Nothing is so precious or so irrevocable as time. Education must develop in the individual the power to appreciate and enjoy life. During his leisure hours he must store up joy, strength and inspiration.

Training in the good use of leisure is worked out in most junior high schools as a regular school activity that provides for a club hour during school time. That the possibilities of clubs may be concretely demonstrated, illustrations are drawn entirely from one school.

THE CLUB IDEA

The club idea, like that of every other activity of Washington Junior High School, had its beginning in the desire to recognize and serve the needs of youth. A school's service to the future makers of America does not end with preparing them for working hours which occupy only a third of the day. It must also provide specifically for the worthy use of leisure. And so there came a willingness among the faculty to share personal hobbies with the student body. Why was it not practical to inaugurate a system which would permit kindred spirits to gather once a week, each one doing at that time the thing he enjoyed most? Thus